Ropes and rigging for amateurs —a professional approach

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PERHAPS the most important link in the radio communications chain is the aerial; the most powerful and sophisticated equipment in the world becomes a useless heap of junk when the aerial is lying on the ground. Aerial experiments also form one of the most interesting and fascinating branches of amateur radio but, while most amateurs are completely at home with a soldering iron in the shack, many feel a lack of confidence when it comes to erecting a mast and rigging an aerial.

Much has been written on aerial theory but scant attention has been paid to the equally important practical aspect of aerial erection. Electronic lash-ups are sometimes acceptable in the shack, where it is a simple matter to re-make the odd dry joint or broken connection, but aerials have to withstand the rigours of the elements and must be constructed with much greater care and expertise if they are to offer any degree of reliability. Knowing the right knot, and how to tie it, is just as much a part of the "compleat radio amateur" as the ability to make a sound soldered joint. Rigging masts and wire aerials is a direct application of elementary seamanship and it is the purpose of this article to translate seamanship into "aerialmanship".

Rope

Rope comes in a wide variety of sizes, materials and forms of construction (known as "lay"). The most popular form is the traditional 3-strand variety with the "right-hand thread" because it is the strongest. It is given a right-hand twist because most people are right-handed and it is their natural tendency to coil the rope in a clockwise direction, which is correct.

Before discussing the multiplicity of materials let us be quite clear about its size. In Britain, rope is—or was—traditionally measured by its circumference in inches. This confuses most engineers, who are more used to considering something of round section by its diameter. Very roughly, the diameter of rope is about one third its circumference. So a ¾in rope is about ¼in in diameter. Under metrication, however, all this will be changed and rope will then be measured by its diameter in millimetres and a ¾in rope will thus become a 6mm rope.

Until comparatively recently all rope was made of one of several vegetable fibres such as hemp, manilla, cotton, sisal etc. Although these fibres have different characteristics, they all have one failing in common—they absorb water, swelling in both length and diameter in the process, and they are attacked by bacteria and rot. For this reason rope was never very popular for use as permanent mast guys as it required continual adjustment and frequent replacement. Guys were therefore invariably made of galvanized wire, although this, too, eventually corroded, and they also had to be split up into short lengths by insulators to reduce the absorption of rf.

Modern ropes made from synthetic fibres offer a tremendous advance in that they do not swell when wet; they resist petrol, oil, acids and alkalis well, and, above all, do not rot. Also, synthetic ropes are generally much stronger than natural fibre ropes and are, therefore, ideally suited for use as guys.

Basically the principles of ropemaking have not altered for hundreds of years. Threads of the fibre are first twisted into yarns which are then laid together in a spiral twist to form the strand and, finally, the strands (usually three) are laid around each other to complete the rope. This method puts an even load on all parts since all the threads run more or less straight along the direction of the load. Look at a rope and see.

With synthetic fibres, however, there is one important difference. Natural fibres, which make up the basic yarn, occur only in short lengths called "staple" fibre. It is the loose ends of these fibres sticking out of the side of the rope which gives it the familiar hairy finish. Synthetic fibre, however, comes in a continuous filament—each one as long as the rope itself. This contributes to the greater strength of synthetic rope and also gives it a much smoother, shinier finish. This can make the rope slippery and difficult to grip, so sometimes the continuous filament is cut into short lengths to resemble staple fibre, thereby giving it the traditional hairy finish. It does weaken it a little, however. The continuous filament also allows the yarns to be plaited or braided. This makes for a kink-free rope (very popular with water-skiers) but it is not as strong as the conventional three-strand construction and it is much harder to splice.

One undesirable feature common to all synthetic rope is the fact that it melts. This is of little significance for most general purposes but it has to be watched very carefully by a seaman when easing a rope round bitts or cleats. This feature can be turned to advantage, however, as it obviates the necessity of whipping the ends to prevent fraying—while this is still the best way, a quicker method is to fuse the end in a clean flame then round off with wet fingers to prevent it sticking. This is best done before cutting; rotate a 1in section of rope in a clean flame until fused all round then cut through with a sharp knife when cool. The two jobs can be done in

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one by using a hot soldering iron (the professionals use an electrically-heated knife blade). The traditional method of whipping can still hold its own on a windy day, though, so is best not forgotten!

Just as the various natural fibres have differing characteristics, so do the various synthetic fibres and, to enjoy the full benefits, it is vital to understand their differences.

Nylon. This is a polyamide filament derived from coal and oil; it was one of the first synthetic rope fibres and is still the strongest. For example, a dry nylon rope of 1in circumference ($\frac{5}{16}$in or 8mm dia) and of conventional three-strand construction (hawser-laid), will break at about 1·3 tons. White in colour, it tends to be rather hard to handle unless plaited or braided. It absorbs a little moisture and loses about 10 per cent of its strength when saturated. It resists strong alkalis well but is expensive.

Nylon's most important characteristic is its fantastic elasticity, enabling it to stretch up to 20 per cent before breaking. This makes it ideal for use in situations where high shock loads would normally break a wire—such as in towing, for example. By the same token, however, this feature makes nylon most unsuitable for supporting a mast; the guys could be tuned like guitar strings but the mast would still wave about like a Caribbean palm! However, nylon would be suitable for use as an aerial halyard; the elasticity would keep the wire taut under all conditions of wind and temperature, but there are cheaper ways of obtaining this desirable effect. Do not make the common error of referring to all synthetic rope as "nylon". If you ask for nylon in a ship chandler's, nylon is what you will get but it may be useless for your purpose.

Terylene. This is a polyester filament derived from oil. It is very similar in appearance to nylon but not quite as strong; the same 1in three-strand rope breaks at about one ton, but this strength is maintained when wet. In some respects Terylene is the converse of nylon in that it resists acids well and stretches very little under load. The small amount of stretch can be reduced still further by a pre-stretching process during manufacture, making Terylene a virtual non-corrosive substitute for wire with the added advantage of also being non-conductive. Pre-stretched Terylene is, therefore, the ideal rope to use for mast guys and halyards, but it is also, unfortunately, the most expensive.

Terylene is the trade name of ICI. The same material is made in the USA, where it is called Dacron by Du Pont, and by Hoechst Chemicals in Germany, where it is called Trevira. To avoid confusion, many rope manufacturers now describe the material as polyester.

Polythene. Also derived from oil, this was the first cheap general purpose synthetic rope fibre and is often referred to as "Courlene", which is the trade name of the basic fibre. In its early days it was always coloured bright orange but it is now available in a variety of colours, including black and white. The fibre, and therefore the rope, is hard, wiry and very smooth; the surface always feels greasy so this rope is easily recognized. It is about 50 per cent stronger than natural fibre ropes but not as strong as nylon or Terylene; the 1in size breaking at about 1,500lb. Under load the stretch is a little less than nylon but much greater than Terylene. It is very light in weight and floats.

When it was first introduced, polythene rope became very popular for general use on account of its low cost, the price being less than half that of Terylene. There are snags, however, the main one being the extreme difficulty in making knots and splices hold securely due to its springy and "greasy" nature. It is still, surprisingly, popular for use in the manufacture of fishing nets, but for general purposes its popularity rapidly declined with the introduction of polypropylene.

Polypropylene. This is another oil-derived polyester fibre and the latest introduction into the rope field. It is the current most popular all-round general purpose rope on account of its excellent compromise with regard to performance and price. It has 90 per cent of the strength of Terylene (the 1in size breaking at about 2,000lb), yet is only half the price. Under load it stretches slightly more than Terylene but nothing like as much as nylon or polythene. It combines the acid-resistance of Terylene with the alkali-resistance of nylon. The fibre is a little harder than Terylene or nylon but not as hard or as "greasy" as polythene. It is light and floats.

When first introduced it was invariably sold under the fibre's trade name "Ulstron" and coloured green, but it is now available in a wide variety of forms and colours. The basic fibre is commonly a continuous round section filament about the thickness of a human hair called "monofilament" when made up into rope. It can also be supplied as an extremely fine strand which is then called "multifilament" in rope form. This form is much softer and more flexible than monofilament but is more expensive because of the extra work involved in manufacture. The fibre may also be rectangular in section; this is obtained by slitting a flat sheet or film of the material which is then called "fibrefilm". This results in a coarse rope which tends to be rather rough on the hands but it holds knots and splices much better than any other continuous-filament rope. In addition, the monofilament fibre can be cut into short lengths to produce a staple-fibre rope of the traditional hairy appearance. Thus, this one basic material can be used to produce four very different types of rope, all with a similar strength!

These, then, are the current most popular ropemaking materials. For amateur radio use, pre-stretched Terylene/Dacron/Trevira makes ideal guys and halyards but is expensive. As this material suffers less from ultra-violet degradation than most other fibres, its use is especially recommended in those parts of the world which enjoy more than their fair share of sunshine. Nylon is unsuitable for guys but could be used for halyards, although this, too, is expensive. In the UK, Northern Europe and other places which would welcome some more sunshine, monofilament polypropylene, although quite a mouthful, is an excellent general-purpose rope equally suitable for use as guys or halyards at a price which will give years of reliable service at little cost.

Thimbles

Whenever the end of the rope is formed into a loop to transfer strain to a metal fitting such as a hook, eye-bolt or pulley, it **must** be protected by a thimble to spread the load correctly and prevent chafe. This is especially important with polypropylene which seems to be particularly susceptible to chafe. Thimbles are commonly pear-shaped troughs of suitable size to take a particular size of rope but they can

also be circular for special purposes. They may be made of galvanized steel, stainless steel or nylon. The stainless ones are extremely strong and expensive and are usually reserved for use with stainless steel wire. The traditional galvanized ones are "cheap and cheerful"; the finish tends to be rough, which partly defeats their object, and they eventually corrode anyway. They can also set up a highly corrosive electrolytic action if used in contact with a dissimilar metal at sea or in coastal areas. For synthetic ropes nylon thimbles are preferred; they cost very little more than the galvanised ones but cannot corrode, cause electrolytic action or damage the fibres.

Thimbles are measured by their overall length but the "score" (width across the trough) is also taken into consideration as this must suit the size of rope it is to take. When a thimble is spliced into the end of a rope it is known as a "hard eye"; without a thimble the spliced loop (eye-splice) is called a "soft eye".

Shackles

These are commonly D-shaped devices (although there are other shapes for special purposes) to link hard eyes, pulleys, eye-bolts, pickets etc. The author's wife calls them "nautical safety-pins" and they may be made of galvanized steel, stainless steel, manganese bronze or even nylon. Like chain, they are measured by the diameter of the bar from which they are formed and can range from $\frac{1}{4}$in to 2in or more. In the smaller sizes the diameter of the screwed pin which forms the stroke of the D is usually the same as the rounded part but, in the larger sizes, the pin is often one size larger.

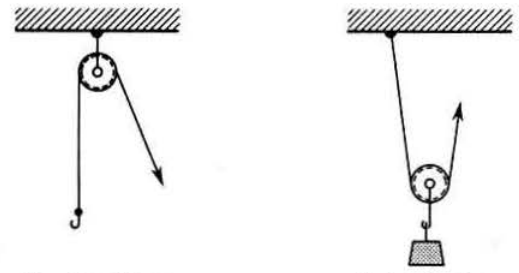
Stainless steel shackles are very strong and last for ever but are extremely expensive and are usually used where expense is no consideration. The galvanized ones are strong and cheap but eventually rust where the plating is worn through at the points of contact, and the threaded parts, which cannot be galvanized, quickly seize with rust unless treated with thick grease—preferably anhydrous lanolin—at frequent intervals. Shackles made of manganese bronze are not as strong as those of steel but have the advantage that they cost only a little more than the galvanized ones but do not corrode. Nylon shackles are usually reserved for use with nylon chain which finds such light-duty applications as mooring marker buoys or marking out exhibition stands etc. The choice usually lies between galvanized or bronze.

The unthreaded end of the pin is flattened and has a small hole through it. It is tightened by slipping it into the tapered slot in a special key or in the side cheek of a seaman's knife—not, please *not*, with pliers. Alternatively, the pin may be tightened by passing a thin, hard steel bar, such as a small Allen key, through the hole, but the main purpose of the hole is to enable the pin to be "moused", that is locked, by twisting wire through the hole and round the bar. For long-term use, especially at sea or in coastal areas, the wire should be of similar material to the shackle to avoid electrolytic action, ie copper wire with bronze shackles and galvanized wire with galvanized shackles. Marine grade stainless steel (EN 58 J) does not cause electrolytic action, so wire of this material may safely be used with any shackle or rigging screw and any non-corrosive wire such as copper may be used with stainless shackles.

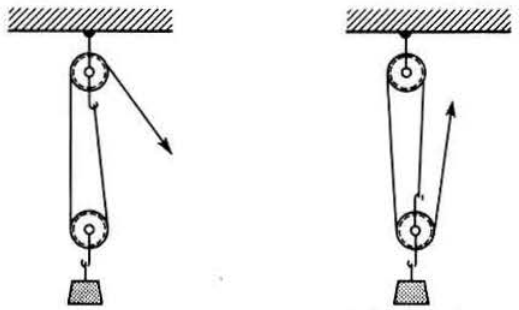
Pulleys

For reliable service in any weather conditions, only genuine marine fittings should be used. They cost somewhat more than cheap washing-line pulleys but are a much better investment as they do not corrode, jam or seize, and require no lubrication or maintenance. Modern marine pulley blocks may be made with synthetic resin bonded fibre cheeks and sheaves and chromium-plated manganese bronze bearings and straps, or with stainless steel cheeks and nylon sheaves. The stainless type costs fractionally more than the other type but there is little to choose between the two in terms of strength and reliability. There is a **minimum** diameter of sheave for every size of rope and there may be up to three sheaves in one block.

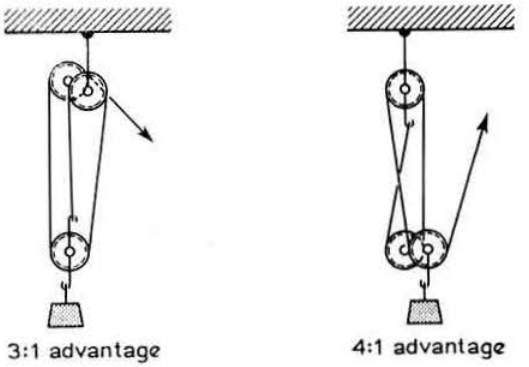
For a simple halyard pulley, a straightforward single-sheaved block will suffice but to make up a tackle for raising a mast (or lifting out the car's engine) one of the pair of blocks must be provided with a becket. This is simply a point of attachment below the block for securing the fixed end of the rope. The apparent power gain varies directly as the number of ropes at the **moving** block. Thus, two single-sheaved blocks, one with becket, will give a 2 : 1 advantage in one direction and 3 : 1 in the other. A single and double gives 3 : 1 or 4 : 1, and a pair of doubles gives a 4 : 1 or 5 : 1 advantage according to the direction of pull. The term "apparent power gain" is used because power is a function of time and although a lifting tackle (pronounced *Tayckle*, by the way) may be rigged to give a 4 : 1 advantage, it will take four times as long (and five times as much rope) to do the job. In fact about 25 per cent of the advantage will be lost through friction in the sheaves.



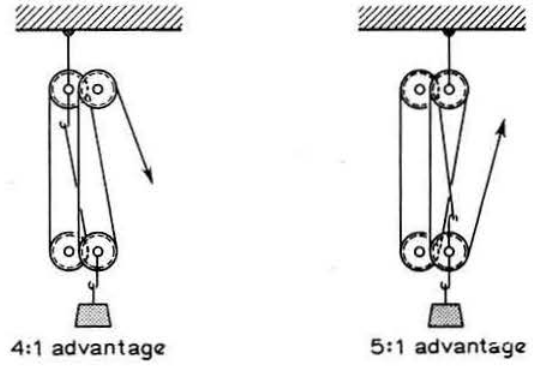
Single whip



Gun tackle



Luff tackle



Double luff tackle

Aerial wire

Have you ever wondered how the GPO land-lines remain intact year after year although your aerial frequently collapses? The Post Office is the world's expert in stringing wire between poles *and keeping it there*. One of their secrets is in the wire which is made to their own special recipe. The addition of one per cent of cadmium to the basic copper increases the tensile strength of hard-drawn wire by 50 per cent from 20 tons psi to 30 tons psi. It also increases the dc resistance by nearly 25 per cent but do not let this worry you too much; the vital thing is to keep some wire up in the air. Your highly-conductive pure copper aerial is quite useless laid on the ground. In the days of airborne hf communication, the RAF used quite thin stranded stainless steel aerial wire, and modern yacht installations invariably utilize part of the galvanized or stainless steel rigging for the aerial. And remember, stainless steel has a dc resistance nearly 53 times that of copper!

Telephone wire is rather quaintly measured by its weight per mile; standard sizes being 40lb, 70lb and 100lb, which approximate to 18, 16 and 14swg, respectively. Either the 70lb or 100lb sizes make good aerials. An aerial "farm" of hf rhombics and dipoles constructed entirely of 70lb telephone wire has been in successful operation for many years at the University of Sheffield's Radioastronomy Research Station 1,350ft up in the Yorkshire Pennines—and a very bleak spot it is too! The same Department of Physics also used this wire at their research station with the British Antarctic Survey, so do not blame British weather for your aerial's demise! British Standard Specification 175/1951 reveals all about telephone wire.

Another secret, which goes hand-in-hand with the wire, is the method of joining and fastening it. A copper tube 3½in long and of oval section, just large enough to take the two wires side-by-side, is placed in a simple hand tool which clamps the ends while the centre section is rotated through 360°. This cold-welds the wires quickly and easily, making a perfect electrical and mechanical joint without annealing the wire.

If plain copper wire is used it **must** be of the hard-drawn variety; common sizes being 14swg or 7/·029. Hard-drawn wire is usually left bare, although it can be covered; it cannot be enamelled as the drying process anneals it.

Joints and fastenings

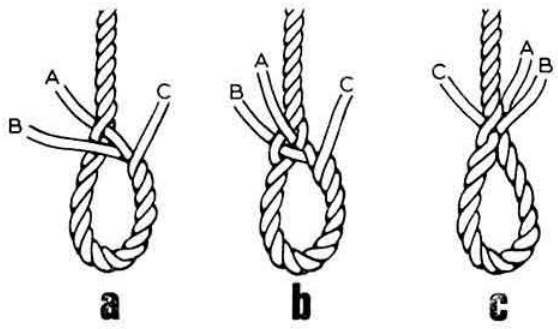
With wire aerials, solder should never be used to make a mechanical joint. The necessary heat anneals the section of wire, making it soft, and the solder stiffens the joint so that tension and movement quickly fractures the wire at the joint. Unless telephone wire and the special "sleeve jointing" are used, there is little one can do with solid wire except to form a loop through the eye of an insulator or round a thimble and wind the short end round the standing part. It is easier on the fingers if the short end is first passed through a small hole near the end of a short piece of wood which can then be turned like a key. Do not try tying knots in wire!

With stranded wire the GPO uses an excellent, but simple, splice. The loop is formed and the short end laid alongside the standing part. Then one strand of the short end is untwisted back to the loop and wound tightly round both parts. Another strand is treated likewise and so on until the one remaining strand is wound round the standing part alone. This results in a beautifully tapered splice of great strength. The GPO standard is a minimum of two and a half turns of each strand and it is recommended that at least four turns be made. Have a look at the stay on a telegraph pole.

If the stranded wire is insulated and there is some reluctance towards stripping the covering, the two parts can be bound together by a flat seizing using waxed or tarred whipping twine. Do not use the new Terylene whipping twine; it is extremely strong but it slips. If the proper waxed twine cannot be obtained, ordinary thin string can be used provided it is made waterproof afterwards by melting—in beeswax or even candle wax with a warm soldering iron. This method is ideal at the elbow of an inverted L to avoid cutting and rejoining the wire. The temptation to use bulldog grips should be avoided at all costs. Not only are they extremely ugly and unseamanlike, they cripple copper wire and reduce its strength enormously.

For a temporary job, rope can be tied to an insulator with a bowline. This is an excellent knot for making a loop, being one of the few knots guaranteed not to slip under any circumstances and is readily untied. However, it is not generally appreciated that all knots greatly reduce the strength of the rope and should be regarded as temporary fastenings only. In the case of the bowline the strength is reduced to about 65 per cent. For a permanent job an eye splice is far superior, retaining 90 to 95 per cent of the rope's

The eye splice



(*a*) **Break open the fused end of the rope, making sure that the individual fibres of the three separate strands remain firmly fused. Unlay 3 or 4in of rope; form a loop in the form of a "U" with the unlayed end on the right. Arrange the three strands so that two of them go off to the right and the third to the left, from underneath. Tuck the centre strand (A) under a strand of the standing part at the point at which the splice is required to start.**

(*b*) **Take the third strand (B), pass it *over* the strand under which the first tuck has just been made and tuck it under the next strand round. Always work from *right to left*.**

(*c*) **Turn the work over and tuck the remaining strand (C) under the one strand of the standing part now showing, *working from right to left*. Watch this move carefully as it is the most likely place for an error to occur. The usual mistake is to make the tuck from left to right as this seems to be the natural way.**

If all is well, you should now have a strand of fibres radiating equally from each "crack" in a section of the standing part. OK? Then, believe it or not, you can now make an eye splice! All that now remains is to take each strand in turn, starting with any one, pass it *over* the strand in front of it and *under* the next one, pulling tight each time. Carry on ad infinitum until you run out of rope. In natural fibre rope a *minimum* of three tucks is required for reliability but with synthetic fibre rope *at least* five should be made. It is important to remember that these are ABSOLUTE MINIMUM figures; no marks will be lost for making many more but something vital like your mast, a ship or even a life may be lost if fewer tucks are made.

To finish off, when there is insufficient strand left to make another tuck, trim the strands to within about ⅛in of the rope with a hot soldering iron. Do not trim off too close or the tuck may pull out. Roll the splice under foot or between the palms of the hands to even out the tucks.

To make the tucks, the rope can be opened up by holding in the left hand and turning clockwise with the right. If the turns are too tight, an opening can be forced by inserting a blunt, tapered spike—a pencil makes a good substitute for the professional lignum vitae fid.

A hard eye is formed in exactly the same way except that the loop is formed round a thimble and the first tuck made as close to the thimble as possible. Work is made easier if the rope is temporarily seized to the thimble with light twine until the splice is finished.

strength, and it is much neater into the bargain. Besides, it is the mark of the expert and impresses visitors enormously. Do not betray the secret that splicing is one of the few things which turns out to be much easier than it looks. All the knots, splices and seizings used in superior aerialmanship can be learned in an hour for the price of a packet of cigarettes. Because of the smoother nature of synthetic rope, splices must be given a minimum of five tucks.

Masts

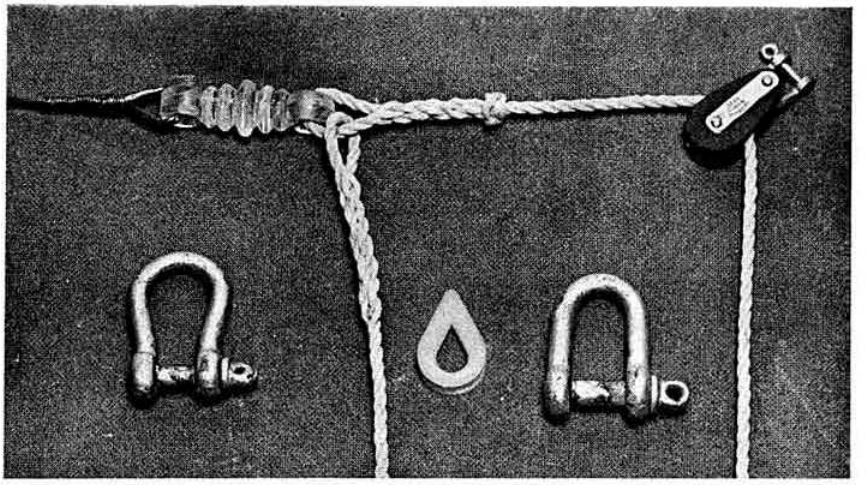
Apart from the conventional flag-pole, a wide variety of ideas has been successfully tried by ingenious amateurs. A lot depends on what can be obtained locally in view of the transport difficulties, and also whether the mast is to support a wire or beam, or is to be used as the radiator itself. Excellent masts have been made from builder's scaffold poles (especially the dural variety), lengths of galvanized gas or water pipe screwed together, and even empty beer or oil cans soldered together. The new plastic fall-pipes can also be stacked to make good mast radiators by taping four lengths of copper wire to the outside. The *Radio Amateur's Handbook* (ARRL) usually contains several excellent suggestions for masts constructed from lengths of timber. However, whatever form the mast takes, unless it is of the self-supporting Eiffel/Blackpool tower variety, the principles and practice of staying it remain the same.

Earth

With most end-fed wire aerials, especially low-impedance ones less than half a wavelength long, a good earth connection is as important as the aerial itself as it forms part of the radiating system. The usual method is to make connection to buried water tanks, large plates, copper rods or tubes, or buried wires radiating from the base of a mast radiator. The success or failure of an earth system largely depends on the conductivity of the ground beneath the aerial. Ground of poor conductivity makes life very difficult and any means of improving the path of rf back to the transmitter will pay handsome dividends. Wire boundary fences can often be bonded together, while one enterprising amateur, who put out such a thunderous signal on Top Band that it crossed the Atlantic many times, even managed to connect together the metal roofs of the entire pre-fab estate on which he lived!

If you are taking over a newly-built house, a more practicable suggestion worthy of consideration is to cover the garden, or a section at least, with galvanized chicken wire before the seed is sown or turf laid. Your new neighbours will think you are mad and may try to avoid you, but if you tell them it is to ensure a weed-free lawn (or some other equally preposterous rubbish) they may even do likewise. You never know your luck! A full roll of chicken wire measures 150ft by 6ft and could be laid in a single strip beneath a Top Band aerial or cut into shorter lengths and laid side-by-side, binding and soldering together every foot or so. At the author's station, which is on the top of a mound of solid chalk several hundred feet thick, the garden is 30ft wide, so a roll of 2in mesh was cut into five lengths and laid across the garden. This makes the entire end of the garden, 30ft by 30ft (900ft²), beneath the mast radiator very highly conductive. This is backed up by four 150ft radials of 7/·029 bare copper buried along the line of the neighbours' boundaries. As the neutral side of the public supply mains is earthed at the source, the effectiveness of an earth system is simply checked by connecting a heavy load between it and the live side and measuring the volt drop. Experiments in this direction can be very illuminating—or not, as the case may be! The author's earth system will run a 2kW electric fire with a drop of only a few volts.

Even a good earth can be wasted unless a really low-resistance connection is made to it. Marine radiotelephone installations, even low-power ones in yachts, use a copper



"Far-end" mock-up showing stranded wire spliced to insulator, yacht pulley and halyard spliced to insulator (finished off with wall-and-crown knot) and free end of halyard spliced through main splice. Also shown are samples of a thimble and two shackles. The "bow" shackle enables two thimbles to be accommodated

earth plate of at least 9ft² (or a patented gold-plated device which claims an area equivalent to 10ft²) fixed as low down as possible below the waterline and make connection to it via copper strip 50mm (2in) wide and 0·5 mm thick and a large brass bolt which is brazed to the plate. This size of earth strip is extremely convenient to use; it bends easily and can be run through door jambs and windows and under carpets very unobtrusively. This arrangement, and the almost perfect earth on which boats float, accounts for the much superior results obtained on the marine 2MHz band over average amateur Top Band performance.

Halyards

For most applications the $\frac{3}{4}$in circumference ($\frac{1}{4}$in, 6mm dia) size Terylene or polypropylene will be ample; only a really large or heavy array will require anything stronger. To prevent premature fracture due to movement in the wind, a wire aerial should be kept under constant tension. One method is to hang a weight on the lower end of the halyard, taking care to lash it loosely to the mast to prevent it blowing about. On professional installations a short weighted lever is usually fixed to the base of the mast. For amateurs it is easier and cheaper to incorporate a small spring close to the insulator at the far end. The type of spring used to tension small boat steering wires is ideal; they are made of galvanised or stainless steel and cleverly arranged so the spring is actually under compression and virtually unbreakable.

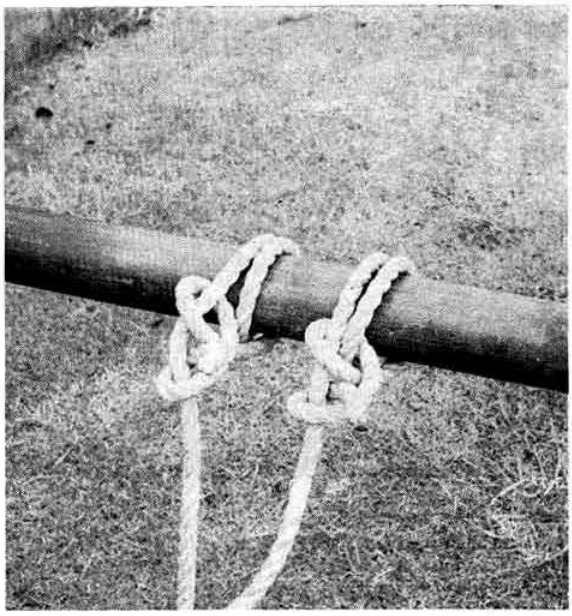
Perhaps the best way of all is to borrow marine radiotelephone technique and fit a neoprene insulator. This is a 24in length of synthetic rubber bar with a hard eye at each end and performs the dual purpose of insulating the aerial and providing tension. The halyard should be spliced to the insulator, taken through a pulley to the ground, and then back to the insulator where it is spliced through the first splice. This ensures that the halyard and insulator can be recovered should the aerial break. It also obviates the necessity of stowing a great heap of rope when the aerial is in position. For a really superior job, the main halyard splice should be finished off with a wall-and-crown knot. This puts a decorative knob at the end of the splice which prevents any tendency for the splice to be pulled into the pulley and jamming it. If the halyard lies close to the mast, wind will slap it against the mast at frequent, regular intervals causing chafe and driving your neighbours to distraction. This can be prevented by positioning the pulley a foot or two away from the top of the mast or by giving the halyard two or three turns round the mast after the aerial has been raised.

If a tree is being used, some form of automatic tensioning device becomes vital. As the pulley cannot be shackled directly to a tree it must be shackled to the hard eye at the end of a length of rope, which is then tied to the tree with a round turn and two half-hitches if the strain is at right-angles, or a rolling hitch if it is not.

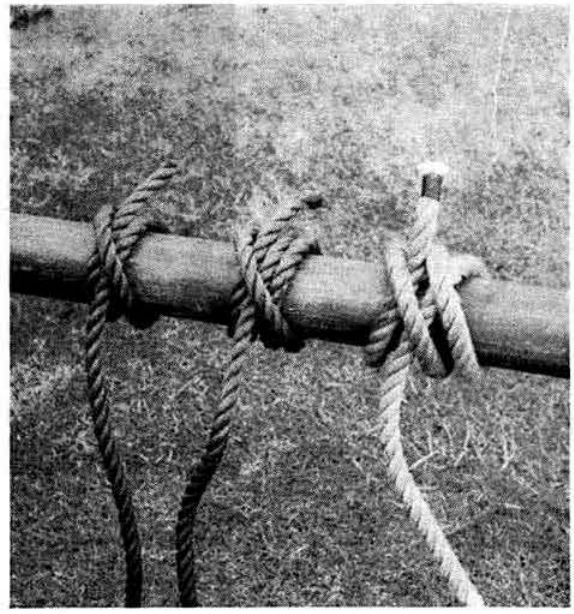
Guys

Non-rotting, non-stretching, non-shrinking, non-rf-absorbing Terylene or polypropylene makes excellent guys for radio masts. For light masts such as the 30ft by 1in ex-Army jobs the $\frac{3}{4}$in circumference ($\frac{1}{4}$in, 6mm dia) size with a breaking load of 1,200lb will probably suffice, but for anything heavier, or in case of doubt, the 1in circumference ($\frac{5}{16}$in, 8mm dia) size is preferred. This latter size offers an 80 per cent increase in strength for only a 50 per cent increase in cost and is well worth the little extra to sleep peacefully through the winter storms instead of having nightmares about the neighbour's greenhouse. Bear in mind that the Board of Trade recommend that the maximum working load of a fibre rope should not exceed one sixth of its ultimate strength. In common with natural fibres, synthetics also suffer varying degrees of degradation from prolonged exposure to excessive ultra-violet radiation so it pays to err on the generous side regarding size and accept the increased strength as a bonus.

It is impossible to lay down any hard-and-fast rules regarding the number of sets of guys or the number of guys to a set as so much depends on the characteristics of the particular mast and the ground area available. As a rough guide, three guys to a set on a pitch circle diameter at least equal to the height of the mast is a good basis on which to start. A thin, flexible mast, such as the 30ft ex-Army job just mentioned, will require guying every 15ft or so, whereas a sturdy flag-pole may manage with one set at the top only. In theory only three guys per set are necessary but it may be



ROUND TURN AND TWO HALF-HITCHES on the left is the basic knot for making fast to a post where the strain is at a near right-angle. It is very secure, quickly and easily tied and is one of the few knots which can be tied while there is a strain on the standing part. The two half-hitches actually form a clove hitch.
FISHERMAN'S BEND or **ANCHOR BEND** on the right is a variation in which the first half-hitch is taken *inside* the round turn. It is even more secure than the basic round turn and two half-hitches but it cannot be tied under load and is difficult to untie. It is ideal for permanently securing a pulley to the branch of a tree

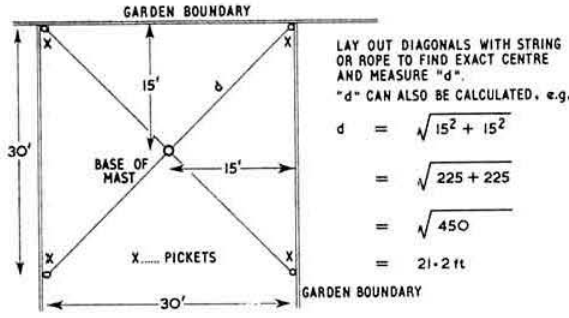


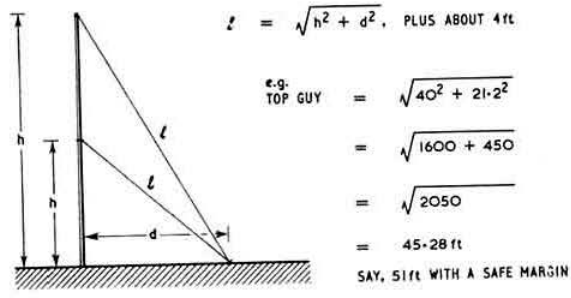
CLOVE HITCH on the left is also a simple secure knot for tying around a pole or post where the strain is at a near right-angle. It is simply a couple of half-hitches back-to-back.
ROLLING HITCH in the centre is a development of the clove hitch with two turns before the cross-over instead of one. It should be used when the strain is more-or-less in line with the pole *against* the two-turn end. If tied on to a rope (either itself or another rope) the second turn should be jammed inside the first as on the right

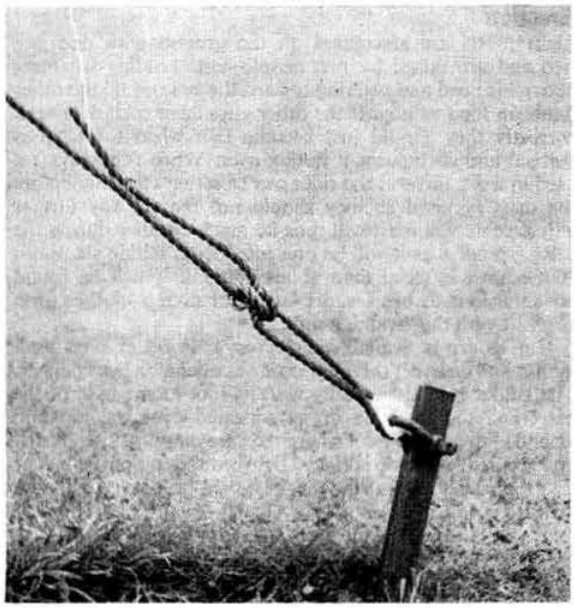
more convenient to use four; a mast at the end of the average rectangular garden can then be anchored to the corners and down the sides.

Guy lengths can be measured by drawing a scale diagram or calculated by courtesy of Pythagoras. As the guy forms the hypotenuse of a right-angled triangle, its length will be the square root of its height, squared, plus the distance from the base, squared. Then add three or four feet extra for splices, hitches etc. See diagrams at right.

Guys should not be set up too tightly; once the mast is being held in position any further tension simply puts the mast under compression, which tends to buckle it in the middle if it cannot be pushed into the ground. This is why high-stretch ropes like nylon and polythene are unsuitable. As a general rule the guys should look tight but not feel tight. If the mast is to support a wire it should be given a slight rake away from the direction of pull so that the aerial will tend to straighten it. This will obviously put a greater strain on the guys behind the mast, but it should not be possible to provide an accompaniment to the Beatles on them! If the mast is stiff enough to support itself without an aerial it should only be necessary to use two guys, spaced about 100° apart, at the top anyway, to balance the pull of the aerial. If the pull is very strong it may be necessary to provide a second set at the middle to prevent buckling.







Guy made fast to an angle-iron picket with a rolling hitch around a thimble on to a shackle

Alternative method of securing a guy to an angle-iron picket by means of a lanyard and large shackle

Pickets

Again, a lot depends on the size and weight of mast and aerial and the nature of the ground but, as a general guide, lengths of 2in outside diameter galvanized pipe driven into the ground at an angle for two or three feet will make a good anchorage. The guy may then be tied directly to the picket using a round turn and two half-hitches, as the strain should be at a near right-angle. When all is settled the surplus rope should be bound to the guy to prevent any possibility of slip and to tidy the loose end. In soft ground it may be necessary to back up the picket with a similar one a foot or so behind, taking a stout lashing from the top of the first one to the bottom of the second.

Lengths of 2in by 2in angle-iron also make excellent pickets; a pair of old Vono bed rails can be obtained very cheaply. With the captive bolts cut off and a 30° cut in the centre of each you have a matched set of four pickets very quickly. Unlike tube or rod, however, the guy cannot be tied directly to the angle-iron; in this case a hole must be drilled near the top (with Vono rails it is already there) and a shackle fitted. If 1in circ (8mm) guys are being used, the shackle should be fairly large—say, $\frac{3}{4}$in or $\frac{1}{2}$in.

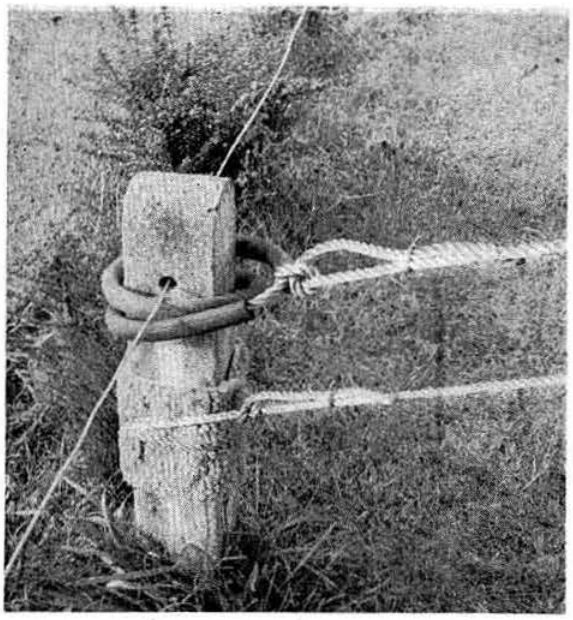
The guy is then cut a little shorter than required and a hard eye spliced in. A lanyard comprising 6ft or so of $\frac{3}{8}$in or $\frac{1}{4}$in circ (3 or 4mm dia) pre-stretched Terylene is then spliced to the eye and passed two or three times through the shackle and eye to form a simple tackle. To spread the load correctly and prevent chafe the diameter of the shackle should at least equal the circumference of the lanyard. Three turns will roughly equal the strength of the guy, and the reduction ratio thus obtained will facilitate setting the tension exactly. This system may look rather crude but it was universally used for the rigging of sailing ships for several hundred years (and still is occasionally) and has proved to be extremely reliable as well as cheap. Have a closer look at *Cutty Sark* or HMS *Victory*.

Alternatively, if $\frac{3}{8}$in circ (6mm) guys are being used to support a light mast, the guy may be passed round a suitable thimble and a smaller shackle can be used. The loop should be formed with a rolling hitch; if this is tied correctly with the second turn jammed inside the first it should be possible to slide the knot up or down the guy to set the length, but the knot should not slide down by itself when left temporarily. When the correct setting has been obtained a seizing should be applied close to the thimble to prevent any possibility of slip.

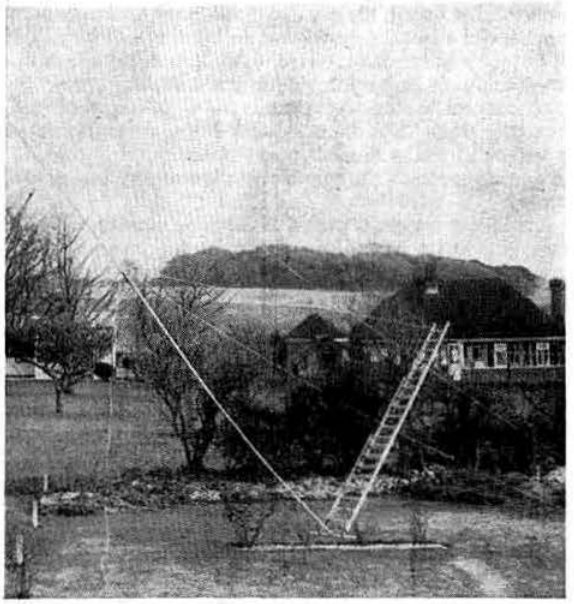
Pickets can also be obtained in the form of a screw made from $\frac{3}{4}$in or 1in bar. Although not strong enough to be screwed into chalky or rocky ground, they are very easy to use in softer ground and are ideal for temporary installations.

Feeder

Most radio manuals contain details of many types of feeder for transferring energy to various types of aerial but fail to mention one very useful tip. Quarter-wave aerials, such as the ground-plane type, present a feedpoint impedance of the order of 25–35Ω at resonance but 50Ω coaxial cable is usually recommended as a feeder simply because coax of a lower impedance just is not made (manufacturers please note). It is not generally appreciated, however, that coax can be connected in parallel, the individual impedances summating in exactly the same way as resistors in parallel. Thus, for quarter-wave aerials, a better match can be obtained by feeding with two 70Ω, two 50Ω, or one 70Ω and one 50Ω cables to give effective impedances of 35Ω, 25Ω and nearly 30Ω, respectively.



Round turn and two half-hitches around a concrete fencing post showing two methods of protecting the rope against chafe with rubber or plastic hose or a strip of old carpet. Strips of old carpet or sacking should also be used to protect a tree branch against the rope biting deeply

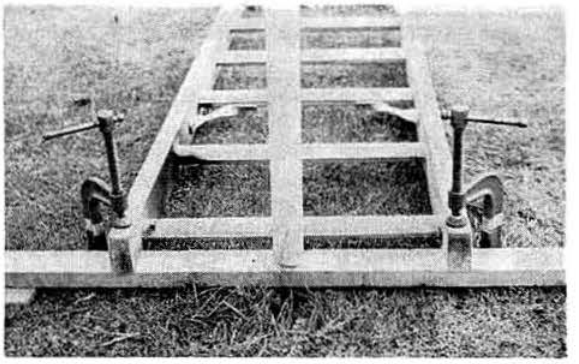


Look, no hands! A 40ft mast in course of erection by the gin-pole method. The whole arrangement is perfectly stable and under complete control at all times. It took the author, entirely unaided, about 45 minutes to assemble and lay out the mast (four 10ft poles) and guys, and 15 minutes to raise it and make the final adjustments

Erection

Light masts are assembled on the ground with one guy free and are raised by two people—one holding the mast above his head and walking toward the base while the other hauls on the free guy. If the other guys have been measured correctly they should just become taut when the mast is vertical and so prevent it falling over. When four guys are used in a set, those at the sides can be set up correctly before the mast is raised as they should not require any further adjustment. The mast will thus be much steadier during the raising process as it will be prevented from falling sideways. If the mast is more than about 20ft tall it will be found advantageous to use a short ladder or even a clothes prop to assist with the "walking-up".

If a ladder is available, however, it is better used as a "gin-pole" or lever; this method is essential with heavy masts. The ladder is held vertically with its foot at the base of the mast and the free guy or guys passed over the top and extended to a lower level where they are more easily adjusted and secured. A tackle is rigged between the top of the ladder and the picket and raising the mast then becomes a one-man operation.



Base arrangement showing a cross-bar temporarily clamped to the *underside* of the ladder. A round-headed screw partly driven into the foot of the mast rests in a hollow in the cross-bar. With the mast vertical, it can now be lifted into a suitable base socket close by, and the ladder removed

With their light-weight 30ft by 1in sectionalized masts the Army suggests they are raised by one man one section at a time, starting with the top like a chimney-sweep's brush, while others hold the guys to steady it. This takes more manpower than the gin-pole method and also takes great skill on the part of those holding the guys—it is difficult for them to judge if the mast is leaning towards or away from them and they must all ease their guys by exactly the same amount as each section is raised. This method really requires the services of yet another person to supervise and is not recommended unless there is insufficient room to prepare the mast on the ground.

More than many others, if this job is worth doing it is worth doing well. If your mast and aerial are rigged according to the principles outlined in this article, you may relax in the comfort of your shack through the storms of many winters. Remember, if it is done properly, it need only be done once.